The diphthongs PRICE and MOUTH in New Zealand English have been characterised as showing ‘diphthong shift’ and ‘glide weakening’. Like most analyses of diphthongs, previous studies have focussed on changes in the qualities of two temporally fixed targets: the nucleus and the offglide. In this paper, by contrast, we model changes in the full formant trajectories of PRICE and MOUTH over a period of 130 years. We first present results from Generalised Additive Models that reveal substantial ‘horizontal’ restructurings in the timing of the trajectories alongside expected ‘vertical’ shifts in nucleus and offglide targets. We then use computational methods to capture these horizontal changes by identifying points of inflection in F1 and F2 trajectories. The timing of these inflection points moves significantly later for both vowels, and shows patterns of phonetic and sociolinguistic conditioning. We argue that changes in trajectory timing are a significantly overlooked aspect of changing diphthong production.