Introduction
Managed grasslands constitute 55% land area and thus the major land use/cover type in Ireland. The characteristics of the maritime climate (e.g. long growing season, frequent rain events) as well as various management practices (e.g. harvest, grazing, re-seeding) may exert strong controls on the exchanges of carbon dioxide (CO₂) and energy with implications on the regional carbon balance and climate. Here we present results from multi-year eddy-covariance (EC) measurements at two intensively managed grassland sites.

Materials and Methods
Ecosystem exchanges of CO₂ (NEE, GEP, ER), and energy (LE, H) were determined using the eddy-covariance technique in two grasslands sites (Dripsey & Wexford) in southern Ireland. Meteorological and soil environmental sensors were installed to monitor environmental conditions. Among years, management was constant at Dripsey (1/3 harvest; 2/3 grazed) but highly variable at Wexford. An annual index of management intensity was developed based on the frequency and duration of individual management events.

Results (1) – Harvest vs. Grazing Effects
Harvest events turned negative NEE (uptake) into positive (loss), reduced GEP and ER; increased H and B for 2-3 weeks. Effects on LE were limited.

Effects on CO₂ and energy fluxes were more moderate after the 2nd cut compared to the 1st cut.

Higher post-harvest Tair and PAR relative to pre-harvest conditions further modified flux response and recovery times following the harvest event in 2006.

In contrast to harvest events, NEE remained negative (uptake) and ER unaffected during grazing periods, meanwhile B increased >1 due to enhanced H.

Effects on CO₂ (energy, i.e. H) fluxes were more moderate (enhanced) during late summer compared to early summer grazing.

Results (2) – Management Regime
The annual GEP-ER ratio and NEE remained stable under similar management regime at the Dripsey grassland. In contrast, the annual ER/GEP ratio, NEE, GEP and B increased while ER, GEP, and E decreased with increasing management intensity/disturbance of vegetation and soil associated with harvest, kale planting and grass re-seeding practices during the growing season at the Wexford grassland.

Results (3) – Climatic Controls
Climatic controls (e.g. Tair, PAR, PPT) resulted in similar GEP and ER responses and thus did not affect NEE on an annual scale at Dripsey.

A prolonged growing season (3 days of GEP > 3 gC/m²/day) of ~235 days may support enhanced annual CO₂ uptake at Wexford.

Results (4) – Global Comparison
Mean annual CO₂ uptake at Dripsey and at Wexford in undisturbed years (e.g. mainly grazed, 2004) is at the upper end of intensively managed grasslands and non-forest ecosystems.

Summary
- Contrasting effects on CO₂ and energy fluxes were observed from harvest versus grazing events.
- The grassland switched to being a net CO₂ source following harvest but remained a sink during and following grazing events.
- Grazing events caused increases in the Bowen ratio via enhanced H fluxes in late summer while similar effect following harvest occurred in early summer.
- Management regime and intensity were related with annual CO₂ and energy balances.
- Enhanced uptake of CO₂ occurred under grazing regime.
- Grass re-seeding and forage crop planting considerably reduces the net CO₂ uptake.
- In comparison with global grasslands, enhanced annual CO₂ uptake in maritime grasslands may be associated with longer growing season.